ing physical relationships between them; i.e. they must reflect the way in which the inputs and outputs are changed by quantitative changes in the products or functions delivered by the system. These "causal relationships" between flows into and out of the system may be represented by a process model, which can also represent the economic relationship of the system. The resulting allocation will not necessarily be in proportion to any simple measured factor such as the mass or molar flows of co-products."

"3) Where a physical relationship cannot be established or used as the basis for allocation, the inputs should be allocated between the products and functions in a way which reflects the economical relationships between them. For example, burdens might be allocated between co-products in proportion to the economic value of the products."

"Any deviation from these procedures shall be documented and justified."

6 Outlook

The standardisation outline found in ISO CD 14041 represents the present basis for the developmental state of LCA. This development is still far from complete. Initiatives taken by SETAC or the EU committee (see LCANET) are involved in this process.

The standardisation procedure cannot be considered as a completed entity, but must routinely undergo further revisions which take the continuing developments into consideration.

Note Added in Proof

Current State of ISO 14041 (March 1997)

Iso 14041 has now left the state of a committee draft and is considered as a DIS (Draft of International Standard)

Life Cycle Interpretation – A Brand New Perspective?

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1 Introduction

Life Cycle Interpretation – a new star on the LCA sky is born! According to ISO 14040, Life Cycle Interpretation is the last formal step in the whole LCA procedure. However, we are all familiar with the iterative nature of LCA as such. So, what does this step contain? One thing is for sure: It is not the former Improvement Assessment as it was suggested by SETAC.

The discussion about the Interpretation step shows the real character of the 14040 series development. It is not alone the standardization of current practice in order to guide users and help interested parties to draw a correct figure of an LCA. It is a process in parallel to the scientific development of LCA and the requests arising from the use of this tool in practice. Standardization of LCA is a struggle for consensus in a methodological development procedure. Nevertheless, the question remains: What does it mean?

2 Aim of Life Cycle Interpretation

Life Cycle Interpretation is a part of the LCA methodology which was introduced, driven from the needs of the users before the background of the problem of how to handle the findings from today's LCAs. Questions like, "What does this difference mean?", "How reliable are these results?" or "Are the findings made in accordance with Goal and Scope?" are constantly being raised – and the LCA framework has offered no solution to the problem.

The interpretation step was invented to provide answers to these questions – an invention which in the light of the day should be quite familiar to all scientists and individuals who are familiar with good scientific practice.

Life Cycle Interpretation is a step before the conclusions are drawn, the step before the decision making process is being fed with the findings in a study. The real aim of this step is to provide reliability and a meaning to the LCA

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study performed. The new framework therefore recommends the use of well known techniques from natural and engineering science.

3 Context Within the 14040 Family

Within the whole 14040 family, the Interpretation step can be considered to be the roof of the famous "Marsmann" building. The following picture may help to demonstrate this. Goal and Scope definition is the foundation of the whole complex. This step covers the rules and assumptions to be used throughout the study, as well as the expectations and needs. On this basis, Inventory Analysis and Impact Assessment can be performed. It is still a very interesting discussion concerning wheather or not the Inventory gives input to the Impact Assessment, with the latter serving to help understand the Inventory a little bit better or *vice versa*. The Interpretation step, however, requires both Inventory and Impact Assessment to meet the requests from the outside world. Even more, the Interpretation step is the clamp – both a cover and protection. A variety of hopes and requests arise from an LCA study. We want to give answers and recommendations with this tool. On the other hand, we fear misuse and a misinterpretation of results. For both applications, the interpretation step provides us with help and guidance for a better understanding of the study results.

4 Procedural Framework

The whole LCA framework serves as a management tool to provide decision makers with information helping to make them better informed decisions. LCA, therefore, is subject to standardization under the heading of environmental management tools. There are a variety of application possibilities: product and process development and/or improvement, strategic planning, marketing or policy making just to name a few. All these applications have to be seen in the whole context including economical, technical, social and other requirements parallel to the environmental considerations as treated by an LCA and other environmental management tools. Therefore, we should not overestimate the meaning of an LCA. On the other hand, we should not forget the unique possibilities which LCAs offer.

The interpretation step covers several procedures and principles aiming at a better understanding of the meaning of the results of a study. Interpretation should therefore be understood in the sense of the original meaning of the words. Interpretation does not replace an Inventory or Impact Assessment, nor does it set new requirements for either.

The *identification of major burdens and impacts* is the first procedure within the interpretation framework. The burdens can hereby be individual interventions, processes or even life cycle stages. For this step, all relevant information from inventory and impact assessment should be available in a disaggregated and ungrouped manner. First, the data used for the analysis is checked for completeness and consistency as requested by the goal and scope. This process aims at ensuring the use of suitable data sets and methods in the earlier process steps. In the same way, data gaps are identified. It is then clarified whether the assumptions made and the data used were adequate to meet the requirements, or whether corrections still have to be made.

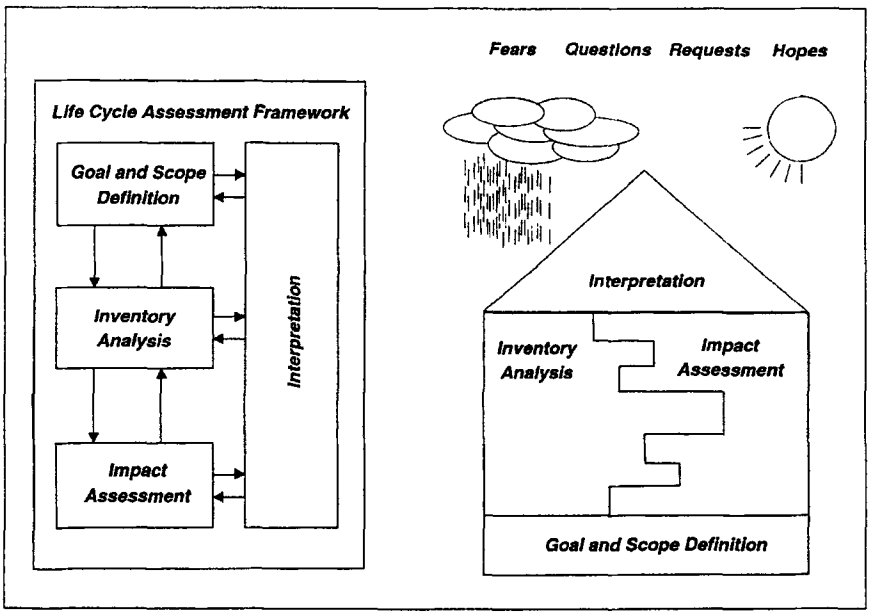

Fig. 1: The LCA framework

All data are then structured by grouping in different ways. The distinctions can be made in life cycle stages, processes or process groups. It is, for example, possible to group data for all transports and energy supplying systems in order to identify their relative share of the overall amounts. Mathematically seen, a contribution analysis is being performed. This means that the relative contributions of the respective processes or life cycle stages are being identified. This gives a first impression of the relevance of each step. This analysis can be performed on the basis of inventory data alone as well as on a combination of inventory and impact assessment data.

In order to arrive at the identification of the relative importance of single interventions or processes, as well as life cycle stages, an evaluation of the findings is necessary.

This *evaluation* must not be mixed up with the evaluation step in the impact assessment. Nevertheless, both steps have some principles in common. In contrast to the mainly objective characterization and classification in the impact assessment framework and the identification of the major contributors in the interpretation framework, the evaluation steps are not based on scientific or numerical procedures, but are mainly influenced by value judgments and can therefore be called subjective. Therefore, both must guarantee a very high degree of transparency and reproducibility.

Evaluation in the impact assessment framework means applying value judgments (individual or policy driven, etc.) on the relative significance of impact categories with one another, including information of the scientific reliability and stability of the models used. Evaluation in the context of interpretation means applying value judgments (again individual or policy, or even socially directed value judgments) on the identification of major burdens, single interventions, processes or life cycle stages. These burdens are identified on an individual basis (values, preferences) including, amongst other things, the knowledge of data gaps and data quality, the knowledge of assumptions in inventory (cut-off criteria, allocation, etc.) and impact assessment (quality and accuracy of the characterization models, selection of impact categories, etc.) as well as the findings from the contribution analysis. This evaluation therefore goes much beyond the limits of a technical procedure alone. The evaluation then allows a further concentration of the data and information volume. The aggregated information is then a basis for the decision-making support.

Nevertheless, this is not enough. To ensure the stability of the findings, a *sensitivity analysis* should be performed. Sensitivity analysis is a tool from operational research. It is a statistical procedure to test the stability of the results when changing single or sets of parameters on the input side. The result is a percentage representing the variation of the result due to a variation in input parameters. Sensitivity analysis should be performed for both, data quality and model quality indicators. In the same way that the inventory data (data gaps, allocation principles, cut-off criteria, etc.) are tested, the methods like characterization models and value judgments in the evaluation step, etc. can be verified. Scenario calculations are also a kind of sensitivity analysis.

Finally, a *consistency check* should be performed. Like the sensitivity analysis and an error calculation, this consistency check is part of a normal scientific procedure for looking at results, before deriving conclusions and recommendations. This consistency check can be looked upon as some kind of critical self-review.

The study is checked for its consistency using the goal and scope definition. Aside from this, accuracy and reliability of the inventory analysis, impact assessment and interpretation procedures are performed. The outcome can be an iterative closing of data and knowledge gaps or the deriving of conclusions in the knowledge of the missing information.

Deriving *conclusions and recommendations* is the final aim of the whole principle. Today, it is unclear whether the conclusions are still part of an LCA or whether they are merely application dependent and therefore not subject to a discussion under the LCA framework. However – it is a fact that decisions are being derived and that conclusions are being drawn. If it comes to the final presentation of an LCA study, the commissioners increasingly demonstrate a situation of providing summaries and recommendations. They should be prepared to do so as well since nobody knows more details about the possibilities and limitations of the whole study.

In engineering and natural science, it is good practice to end a project with a critical discussion on these possibilities and limitations. My recommendation, therefore, is to include rules for such a principle in LCA as well. It does not endanger the tool. It provides additional reliability and credit if we actually do this.

5 Outlook

The discussion about the value and the idea behind the interpretation step is at a very early stage of development. Some more time will be required to further develop the idea. Especially the case studies demonstrating the value are very helpful. In the same way, the more experienced practitioners should provide guidance and advice, the lesser experienced should start working with the tools in order to become familiar with the principles and in order to gain experience themselves. In this way, the standardization of principles and procedures for a Life Cycle Interpretation is becoming possible. In my personal opinion, the interpretation step is the key element toward reliability and an acceptance of the whole LCA framework. We should therefore be very careful to give this flower a chance to grow. These principles are good scientific practice in other applications as well, their use in Life Cycle Interpretation is no longer new.